THE ACTUATOR

Save the Date!

January Meeting:
Driving Hospitals Towards Net Zero
Wednesday January 18th, 2023
at 11:30 AM

Wells Fargo Bldg: Pavilion Conf Rm
601 W 1st Ave, Spokane WA 99201

RSVP Link is live! Click Here.

*Note: This will be a virtual presenter, so please email technologies@ie-ashrae.com if you must attend remotely, and do not RSVP through the website as that is how we determine the count for meals.*
Tentative Inland Empire Chapter Schedule

October 19th, 2022 - Topic: Environmental & Operational Benefits of CO2 Heat Pump Water Heaters 11:30am - 1pm
   Wells Fargo Building, 601 W 1st Ave Spokane, WA 99201

November 16th, 2022 - Topic: Digital Flow and Energy Measurement Solution - 11:30am - 1pm
   Spokane Convention Center, Room 302A

January 18th, 2023 - Topic: Driving Hospitals Towards Net Zero - 11:30am - 1pm
   Wells Fargo Building, Pavilion Conference Room, 601 W 1st Ave Spokane, WA 99201

February 15th, 2023 - Topic TBD - 11:30am - 1pm
   Wells Fargo Building, 601 W 1st Ave Spokane, WA 99201

March 15th, 2023 - Topic TBD - 11:30am - 1pm
   Wells Fargo Building, 601 W 1st Ave Spokane, WA 99201

April 19th, 2023 - Topic TBD - 11:30am - 1pm
   Wells Fargo Building, 601 W 1st Ave Spokane, WA 99201

May 17th, 2023 - Topic TBD - 11:30am - 1pm
   Wells Fargo Building, 601 W 1st Ave Spokane, WA 99201

June 21st, 2023 - Topic TBD - 11:30am - 1pm
   Wells Fargo Building, 601 W 1st Ave Spokane, WA 99201
Driving Hospitals Towards Net Zero
Reducing Greenhouse Gas Emissions and Increasing Climate Resilience

Presenter:
David N. Schurk DES, CEM, LEED-AP, CDSM, CEWP, SFP, CIAQM.

Job Title: Director-Healthcare Vertical and Applied Engineering Markets. ASHRAE Distinguished lecturer, Committee Chairperson ASHE Sustainability and Decarbonization Leadership Task Force, Member ASHE Rapid Response Task Force.
Driving Hospitals Towards Net Zero

Learning Objective:

1. Understand what greenhouse gas reduction involves and exactly what hospital facilities are tasked to deliver.

2. Provide references to industry resources which can be used to help create a road map to success.

3. Explain the various contributors of hospital GHG emissions including direct, indirect, and other source emissions that must be addressed.

4. Define hospital “energy use intensity” (EUI) and show exactly which process within the facility consume the most energy, and why.

5. Outline three opportunities within a hospital that can deliver the largest energy-source reduction and understand practical ways to implement solutions with little or no first-cost consequence.

6. Clarify a simple and effective way to communicate the financial benefit of any energy-efficiency initiative to the CFO, in a manner that will garner a positive response.
Don’t Sweat It
Why Climate and Geography Matter in Chilled Water Systems

BY ALEC CUSICK, ASSOCIATE MEMBER ASHRAE

Chilled water piping is used in a range of situations—from data centers to airports and across multibuilding campuses in district energy systems. Although these systems face several threats—such as condensation and vapor pressure—in terms of long-term function, a properly designed and installed insulation system can preserve longevity. Designing an insulation system to have the required amount of thickness and sufficient moisture resistance coupled with a jacketing that has the right emittance can help mitigate the risks posed by condensation, water vapor and unexpected mechanical damage. Protecting the chilled water system in these ways helps ensure efficient long-term function and reduces the need for unexpected repairs.

Specific challenges need to be addressed when designing insulation to protect chilled water lines and ensure optimal, long-term function. Correctly designing and installing insulation can be a cost-saving practice in the long term because it ensures efficient thermal performance and reduces the likelihood that insulation will need to be replaced before the end of its design life. Replacing the insulation on already installed chilled water piping can be three to four times more expensive than the initial application. This puts an added emphasis on the design of chilled water insulation systems, which may experience damage or even failure from environmental conditions before the building housing the system even opens.

Design Challenges for Chilled Water Lines

The predominant risk for chilled water systems is moisture, which is estimated to cause 98% of the problems faced. Chilled water lines often run at below-ambient temperatures, about 36°F (2.2°C) with system return lines at 50°F–55°F (10°C–12.7°C). The potential for damage means reinstallation of insulation can be needed because of an unexpected system failure after the initial installation.

Moisture can compromise chilled water insulation systems in various ways—vapor pressure can drive moisture into permeable insulation systems, condensation can collect on the outside of insulation systems, and, for outdoor or underground systems, floodwater can wet or engulf piping. If this happens it can lead to several issues, some of which may be immediately apparent, while others take years to become visible. In either case, eventually the wet insulation must be removed and replaced.

Alec Cusick is technical services engineer at Owens Corning in Toledo, Ohio.
Common Issues, Damage From Failed Systems

One of the most noticeable issues with failed insulation on chilled water pipes is dripping water from the insulation. Dripping water could be an indicator that condensation is forming on the outer surface of the insulation or that water has penetrated and saturated the insulation, allowing moisture to re-escape the system. When dripping occurs on indoor piping, it can create a slip hazard, damage ceiling tiles or stain walls and equipment located under the pipes. Additionally, the presence of collected moisture provides one of the elements necessary for the growth of mold, which needs moisture, oxygen and a food source to grow. While most types of insulation do not provide a food source, the material can collect dust, dander or skin cells, meaning only moisture is needed for mold to grow.

The presence of mold indoors negatively alters air quality and has been linked to an increase in many health problems including asthma, allergic rhinitis and long-term illnesses. Additionally, about 6%–10% of the general population is allergic to mold, and the presence of toxic mold has become a topic of increased legal focus in recent years.

Corrosion under insulation (CUI) is a less obvious form of damage that can occur when moisture penetrates pipe insulation. Once moisture enters an insulation system, it can collect against the outer edge of the chilled water pipe and start to degrade the pipe itself. This corrosive damage can take years to develop. However, the hidden damage to pipe integrity can continue until a catastrophic failure of the entire piping system occurs.

In addition to CUI, the presence of moisture within permeable insulation can greatly reduce the insulation’s thermal performance, which leads to a range of problems. Water is an excellent conductor of heat, with studies showing that water can transmit heat or cold 10 to 30 times faster than air. When insulation absorbs additional heat or sees a decline in thermal performance, it can lead to a loss of process control and create a strain on the chilled water system because it will require more energy for the system to reach the necessary temperatures. Increased energy expenditure raises the cost of running the system. Warmer supply lines also mean that climate-controlled areas may not get to their intended temperature.

Preparing for Moisture Vapor

Several key elements should be considered when preparing to address moisture challenges to chilled water pipes, including humidity, vapor pressure, dew point and vapor pressure drive.

Humidity is the concentration of water vapor present in the air. Relative humidity is a percentage ratio that describes the relationship between the actual amount of moisture in the air compared to the greatest amount it could hold at that pressure and temperature. At 100% relative humidity, air has no more capacity to hold additional water as vapor. Humidity varies regionally, making it important to know the conditions of the specific location where the system will be installed (Figure 1).

Vapor pressure is defined as the force exerted by a vapor that is in equilibrium with its condensed phase at a given temperature. Vapor pressure increases with temperature, meaning warmer air spaces of higher vapor pressure will move vapor toward colder areas of lower vapor pressure. This tendency of vapor in the air to move from warm to cold areas is commonly referred to as “vapor drive.”

Vapor pressure can be viewed as the tendency of a material to transition into its gaseous state under ambient conditions, which also will increase with temperature. As temperature falls, water becomes less able to transition into vapor under ambient conditions. In any air space at less than 100% relative humidity, a dew-point temperature exists below which the air will be too cold for water to further transition into a gas. Below this dew point, water will instead begin to freely condense from the air into liquid water. If objects or surfaces in this air space are lower than this temperature, they will cool the local air in contact with them to below the dew point, causing surface condensation, or “sweating,” to occur. This mechanism, along with the “vapor drive”
previously discussed, is the reason condensation remains a cause for concern for insulation failures on chilled water lines.

Insulation System Design, Permeability, Vapor Barriers

When designing an insulation system, one element to consider is the permeability of the insulation to be used. Permeability relates to how willing a material is to allow liquids or gases to pass through it. When using permeable insulation, an external vapor barrier is needed to prevent water from entering the system. If the barrier is damaged, it can allow moisture and water vapor to penetrate the insulation. Activities that can impede vapor barrier function include incorrect installation practices, physical damage, rough maintenance practices and daily traffic. If the barrier is damaged, permeable insulation also can absorb and retain the moisture vapor, which would compromise the thermal performance, or thermal conductivity, of the insulation. Different studies have found that increasing the moisture level within insulation by 1% can reduce thermal effectiveness by 7.5% or up to 23%.\(^{1,10}\)

This shift can lower the external surface temperature of the insulation, attracting more moisture, and allowing condensation to start collecting.

However, not all insulation is permeable (Figure 2). Closed-cell materials tend to have much lower permeability than materials that are open-cell or granular in nature. A low or zero permeability insulation will better protect against water vapor traveling into the insulation, which will help maintain its thermal performance.

Surface Temperature Implication, Calculation

When designing an insulation system for chilled water lines, one important step involves calculating the surface temperature of the outermost layer of the insulation system. Insulation systems of sufficient thickness and surface emittance will have an outer surface temperature that is above the surrounding air’s dew point, mitigating the risk of surface condensation taking place.

Note that the dew-point and calculated surface temperature should account for worst-case scenarios, not just average conditions. This will ensure that the system remains protected against condensation control even during warmer humid days.

The temperature of air (\(T_{\text{air}}\)) and the relative humidity (RH) can be used to establish the dew point. To prevent surface condensation from taking place, the outer surface temperature of the insulation system should be kept above the dew point. For example, if the \(T_{\text{air}}\) is 80°F (26.7°C) and the RH is 75%, then the dew point would be 71.3°F (21.8°C), which could then be considered the lower temperature limit for the surface of the insulation—it should be kept above this temperature. If the outer surface of an insulation system in this environment is found to be 74°F (23.3°C), surface condensation will not take place along the system (Figure 3).

However, because the pipe is well below the ambient temperature, a point will exist within the insulation where the temperature drops below the dew point. As long as an impermeable insulation is used, or as long as the vapor barrier remains effective, moisture will not be able to reach this location and condense.

Jacket Emittance

When determining the surface temperature of an insulation system, one element to consider is the surface emittance of the jacketing material used. Emittance describes how effectively a material emits and absorbs heat by radiation and is most relevant to the outermost surface of an insulation system. The emittance of a given material is
expressed as a ratio between 0 and 1, with a higher emittance meaning more heat transfer will occur between the material and its environment.

When considering jacketing materials for an insulation system, different emissivities can have a noticeable impact on the outermost surface temperature. For chilled water lines, a jacketing with a low emittance, like aluminum or steel, will draw in less heat from a warm environment, resulting in a lower outer surface temperature. However, a high emittance jacketing, such as PVC or kraft paper, would absorb more heat from the same environment, resulting in a higher surface temperature.

One tool that can be used to assist with calculations such as these is the North American Insulation Manufacturer’s Association’s (NAIMA) free 3E Plus® software. As an example of a calculation using this tool, consider two identical 8 in. NPS (200 mm DN) chilled water pipes operating at 40°F (4.4°C), each with 2 in. (51 mm) of mineral fiber pipe insulation (ASTM C547, Type I). Both pipes are within ambient air of 90°F (32.2°C) and no wind speed. Assuming a relative humidity of 80%, the dew point can be calculated to be 83.5°F (28.6°C). In this scenario, new aluminum jacketing (emittance = 0.04) would yield a surface temperature of 81.9°F (27.7°C), which would present an immediate concern for surface condensation to occur, as the outer surface temperature is lower than the dew point. However, the same system applied with PVC jacketing (emittance = 0.9) would yield a surface temperature of 86.7°F (30.4°C), preventing surface condensation from taking place. By considering the effect that jacket emittance has on a system’s surface temperature, one can better protect their systems against surface condensation and the consequences to which it can lead.

**Design Standards**

Design standards exist from different organizations that can be referenced when determining the design of insulation systems for chilled pipes. One such standard is ASHRAE/IES Standard 90.1-2019, *Energy Standard for Buildings Except Low-Rise Residential Buildings*. However, this standard is built around energy conservation requirements for chilled water pipes, not condensation control. When designing against the threat of surface condensation, a hands-on approach that considers operating temperature, regional climate and worst-case scenarios should be used.

**Real-World Complications**

There also are a range of less obvious elements that must be considered when designing a protective system for chilled water lines, as several occurrences could increase the amount of humidity a system has to navigate. One element relates to the integrity of the building envelope in which the system is located. For example, in airports, big frequently opening doors can allow large amounts of unconditioned, ambient air to enter the building and increase the local relative humidity. This would increase the dew point of the surrounding air as well as the vapor drive toward cold surfaces, increasing the risk for surface condensation to occur.

Designers also need to know if the building will be at risk of “idle building syndrome.” When buildings are partially closed or unoperated at times, air handlers may be turned off while the chilled water lines remain in operation. The combination of unconditioned, high-humidity air and chilled pipe surfaces can result in a strong vapor drive toward the cold pipe surfaces, leading to similar challenges, as previously mentioned.

For outdoor chilled water systems, it is important to remember to design against worst-case climate conditions the system will be exposed to, as temperature and humidity can fluctuate greatly depending on the time of year. Areas exposed to direct sunlight should be protected from ultraviolet (UV) damage. Additionally, if the system will be exposed to harsh chemicals, rodent activity or have underground sections, appropriate materials should be used to offer adequate protection accordingly.
For all chilled water systems, it remains important to consider the specific environment of the facility and to account for worst-case scenarios during the design phase, rather than average conditions.

**Direct Buried Piping**

District energy systems, which provide climate control for multiple buildings from a single facility, are increasingly common. This practice can call for pipes to be direct buried or in underground vaults or tunnels.

When chilled water pipes will be encased in soil, weight or compressive strength becomes an additional concern. Any insulation used must have enough compressive strength to support the weight of soil backfill, which increases with soil density and depth. Additionally, pipes and insulation must cope with any weight on top of the soil—either live load or stagnant load—such as foot and vehicle traffic or permanent structures. Without the necessary compressive strength, insulation cannot continue functioning optimally.

Direct buried systems also must address hydrostatic pressure within the soil. Hydrostatic pressure is the pressure exerted by a fluid at equilibrium at any given point within the fluid. It is based on the force of gravity and increases with soil depth. Hydrostatic pressure can drive moisture into permeable insulation systems, as it can be particularly damaging to weak or poorly installed joints. The pressure is of particular concern in areas with a high water table or in locations prone to seasonally high precipitation.

Additionally, soil is not a great insulator. When buried, chilled water lines may be buried near warmer processes such as hot water or steam lines. In this scenario, should the insulation on either system fail, heat would be able to rapidly transfer from the hot pipe to the chilled lines. This would raise the temperature of the chilled water in the pipe, adding additional load to the chillers, increasing energy costs and reducing the overall cooling capability to the building in question.

**Pipes in Vaults/Tunnels**

When chilled water pipes for district energy systems travel through tunnels or in vaults, it is also not uncommon for them to be located next to hot pipes within the same space. These shared spaces can be big enough for people to walk through or small enough to serve as a crawl space, which raises issues of durability. Using an insulation with more compressive strength can protect it from incidental damage of nearby workers, while an inorganic material can help protect against burrowing vermin.

Another challenge with pipes in this situation is the potential for flooding to occur. Although the installation of a sump system can help, these devices are prone to clogging. When flooding does occur, insulation may be submerged and remain covered by water for indefinite periods. If a permeable insulation system is used, it can then absorb and retain flood water, compromising its thermal performance. This potential for flooding to occur highlights the need for an impermeable insulation system and specified accessories, like sealants, to be applied to underground chilled pipes.

**Cellular Glass Insulation**

Closed-cell, cellular glass insulation (Figure 4) has several attributes suitable for insulation material. It is a lightweight, rigid material with a high compressive strength that will not flex or warp even when exposed to weight and a range of temperatures for long periods. Being made of millions of completely sealed glass cells, the material is nonabsorbent, non-wicking and impermeable to liquid and water vapor according to testing to ASTM E96. This helps the material retain its thermal performance throughout the life of the system. The insulation has a service temperature range from –450°F to 900°F (–268°C to 482°C) and is dimensionally stable, with a thermal expansion coefficient similar to carbon steel’s.

**Conclusion**

Keeping moisture away from chilled pipes and out of insulation helps protect the long-term thermal performance of the insulation, enables proper function of the systems, and extends their service life. The use of an impermeable insulation system and specified accessories, like sealants, to be applied to underground chilled pipes is essential to protect the insulation from moisture and maintain its thermal performance.
chilling system and reduces the risk of hazards or critical system failures occurring. However, several challenges remain that must be addressed when designing an insulation system for a chilled water system, including vapor drive, surface condensation and overall durability. When protecting against surface condensation, worst-case conditions include those that are considered when determining the dew point of an area and when determining insulation thickness and jacketing emittance to use on a system. Suitable insulation materials to further protect against vapor drive would be closed-cell, impermeable and nonabsorbent. Additionally, any potential complications from the location of the pipes—indoor, outdoor or underground—should be determined and accounted for.

References

ASHRAE is looking forward to returning to Atlanta – home of the new ASHRAE Global Headquarters. The ASHRAE Winter Conference will be held February 4-8, 2023, at the Omni Hotel at CNN Center and Building A of the Georgia World Congress Center. The AHR Expo is February 6-8 in Buildings B and C of the Georgia World Congress Center.

Please see the following link for more information:

https://www.ashrae.org/conferences/2023-winter-conference-atlanta

ASHRAE related news:

- ASHRAE Commits to Developing an IAQ Pathogen Mitigation Standard
- ASHRAE and Building Industry Organizations Assume Leadership Role in Global Decarbonization Efforts
- Call for Speakers Announced for ASHRAE Developing Economies Conference

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